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The effect of microlearning and multimedia design on knowledge and skills acquisition of students in e-courses

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Abstract

Although the term *microlearning* has been around since 2005 (Hug, 2005), its use, and research in the area, have resurged in recent years as adult learners have become increasingly more mobile and must deal with competing work, family, and educational priorities. Today's learners, in both formal and informal academic and corporate learning environments, can benefit from microlearning's smaller, single objective lessons that can be consumed quickly and easily. However, there are many variations of microlearning and ideas on how to create the instructional materials they include. While it may seem simple, the development process requires applying instructional design strategies and the multimedia tools necessary to deliver short, but effective instructional units. This article describes the results of a quasi-experimental action research project conducted to determine the effectiveness of micro-lessons integrated into university coursework developed using Mayer's (2009) *Principles of Multimedia Learning* on learners' knowledge acquisition and ability to perform a targeted skill.

Keywords: multimedia design, microlearning, eLearning, educational technology

Introduction

Although the term *microlearning* has been around since 2005 (Hug, 2005), its popularity has resurged in recent years as adult learners have become increasingly more mobile and must deal with competing work, family, and educational priorities. Today's learners can benefit from smaller lessons that present a single topic or objective and can be consumed in an accelerated time frame. These characteristics often make videos the *go-to* multimedia used in micro-lessons to help deliver the content. Other times, the videos are the micro-lessons, as advanced technologies now allow designers to add interactivity and assessments directly into the videos.

There are many variations of microlearning and ideas on how to create the instructional materials they include. While it may seem simple, the development process can require a complex combination of knowing how to use multimedia tools to create them and the pedagogical skills to be able to deliver them in short, but effective instructional units. Mayer's (2009) *Principles of Multimedia Learning* can provide guidance in developing effective multimedia for learning. This article presents an overview of microlearning research, as well as the purpose, design, methodology, and results of a study designed to determine the effectiveness of micro-lessons integrated into academic coursework developed using the *Principles of Multimedia Learning* on learners' knowledge acquisition and ability to perform a targeted skill.

Background

Microlearning has been defined by many scholars in the literature (Hug, 2005; Hug & Friesen, 2007; Janjua, 2017; Kapp & Defelice, 2018; Orwoll et al., 2018; Winger, 2018; Buhu & Buhu, 2019; Lin et al., 2019). These definitions commonly refer to a variety of microlearning characteristics but are consistent in that microlearning objects are short and concise. This study uses the definition by Khan (2020), which defines microlearning as a "single objective, focused, outcome-based, stand-alone, meaningful, and interactive learning unit delivered in bite-sized snippets (i.e., a short modular format) either digitally (i.e., via computer, tablet, or smartphone) or non-digitally (i.e., as via a flashcard, infographic, or booklet)" (p. 6).

These characteristics, and the flexibility to apply microlearning digitally and non-digitally, help make microlearning relevant for use in a variety of formal and informal workplace and academic settings. The relevance of microlearning is revealed in its history, during which, according to Agrawal, in 2017, expanded from being used mainly for corporate learning, to use in other environments, such as workplace professional development and training (Buchem & Hamelmann, 2010; Göschlberger & Bruck, 2017; Emerson & Berge, 2018; Zhang & West, 2020); elementary, middle, and high school education (Nikou & Economides, 2018); healthcare (De Gagne et al., 2019; Gross et al., 2019; Mak et al, 2021); and higher education (Grevtseva et al., 2017; Skalka, 2018; Dolasinski & Reynolds, 2021).

The benefits of microlearning have also been reported, including its ability to: help reduce cognitive load while boosting the transfer from short-term to long-term memory (Snelson & Elison-Bowers, 2007; Major & Calandrino, 2018); increase retention (Shail, 2019); and positively impact learner motivation and engagement (Halbach & Solheim, 2018; Nikou & Economides, 2018; De Gagne et al., 2019; Nikou, 2018). As early as 2005, Hug observed, "digital technologies and media institutions have transformed knowledge structures as well as processes of knowledge distribution and knowledge acquisition" (p. 4). However, the *how* of the ongoing transformation process Hug referred to, is still being researched. In addition, according to Taylor and Hung (2022):

> *"While substantial information exists in industry articles and commentaries on the definition of microlearning- along with how to create, develop, and implement it" (Abstract, para. 1), there is still a need for research regarding the effectiveness of microlearning on learners' knowledge and skill development, as well as best practices for development and implementation. "*

Further study is needed to understand how to inform instructional design professionals of current trends and the effects of microlearning training on the enhancement of learner performance in both workplace and academic settings" (Taylor & Hung, 2022, Abstract, para. 1). As such, this current study seeks to contribute to the literature by providing research on micro-lesson design and its impact on learners' knowledge and skill acquisition. Similarly, questions still arise regarding the design of microlearning (length, format, technology, etc.), as well as how to evaluate the effectiveness of microlearning on knowledge and skill development. The following section provides a description of an action research study conducted to determine the effectiveness of micro-lessons integrated into academic coursework developed using Mayer's (2009) *Principles of Multimedia Learning* on learners' knowledge acquisition and ability to perform a targeted skill.

Action Research Project

Writing clear, concise, observable, and measurable performance objectives is an essential job skill of the educational technology professional. Yet, it is a skill that many graduate students struggle with throughout the program. To address this skills gap, a job aid in the form of a web-based *Writing Performance Objectives*

micro-lesson was developed and implemented in the first two courses of the graduate program. Through the presentation of multiple examples and non-examples, the micro-lesson addressed the 3 basic components of a well-formatted performance objective: (1) the identification of optimal conditions under which the learning takes place; (2) the selection of observable and measurable action verbs to describe targeted learner behaviors, and (3) the determination of appropriate criteria for assessing to what degree the objectives are achieved.

While the micro-lesson showed promising results in its first iteration, with an average increase of 21% between the Pre/Post-Skills Checks, the average score of 76.7% on the Post Skills Check fell below faculty expectations. To enhance knowledge and skills attainment, and as an ongoing exercise in continuous improvement, the program faculty opted to revise the micro-lesson. Turning to the research literature, the focus became enhancing the viewability and relatability of the content presented in the multimedia presentation portion of the micro-lesson. Using the *Principles of Multimedia Learning* (Mayer, 2009), based on Mayer's development of a cognitive theory of multimedia learning with Moreno (Mayer & Moreno, 2005) as a guide, the multimedia design focused on adjusting how on-screen text, visuals, and audio narrations interacted with each other on the slides.

Mayer's principles were an appropriate guide for the multimedia design, as his cognitive theory of multimedia learning conceptualizes the human mind as "a dual-channel, limited-capacity, active-processing system" and views multimedia as "not simply information delivery systems," but as "cognitive aids for knowledge construction" (Mayer, 2009, p. 14). Mayer (2009) asserts that as a result, teaching and learning elements that use multimedia should be designed (or in our case, redesigned) to more effectively "manage intrinsic load, optimize germane load, and minimize extraneous load" to help to facilitate the transfer of knowledge from short-term to long-term memory (p. 14).

An action research project was designed to test the effectiveness of the redesigned *Writing Performance Objectives* micro-lesson on graduate students' performance on the Post-Skills Check as well as on long-term retention of essential knowledge and skills. This action research project was designed to address the research questions listed below.

RQ1: *What is the effect of a micro-lesson on learners' knowledge and skill acquisition?*

RQ2: *What is the effect of a redesigned micro-lesson video using* ***Mayer's (2009) Principles of Multimedia Learning*** *on learners' knowledge acquisition?*

RQ3: *What is the effect of a redesigned micro-lesson video using* ***Mayer's (2009) Principles of Multimedia Learning*** *on learners' ability to perform a targeted skill?*

RQ4: *What are learners' perceptions and preferences regarding multimedia design for microlearning?*

Methodology

Research Design

A quasi-experimental design with pre-test and post-test, and non-equivalent groups was selected for the purposes of this action research project. While randomization or matching were not possible as the participants were students already enrolled in 2 sections of 2 fully online graduate courses, the classes were

randomly assigned to either the treatment group or the comparison group. The research design is presented in Table 1.

Table 1: **Quasi-Experimental Design**

Groups	Pre-skills check	Treatment	Post-skills check
1- Comparison group	01	-	01
2- Treatment group	02	X	02

The original and enhanced videos were created in iMovie and uploaded to YouTube. Both videos were created with the same script and were approximately 5-minutes in length. Where they differed was in how on-screen text, visuals, and audio narrations interacted with each other on the slides. The original version resembled a typical multimedia presentation created by faculty. Overall, it was well-developed and looked and sounded polished. The multimedia enhanced video was adapted to address research-based best practices based on Mayer's (2009) *Principles of Multimedia Learning*. The completed videos were embedded into two identical micro-lessons created in SoftChalk Cloud. Figure 1 below presents side-by-side images of the original and revised micro-lesson videos.

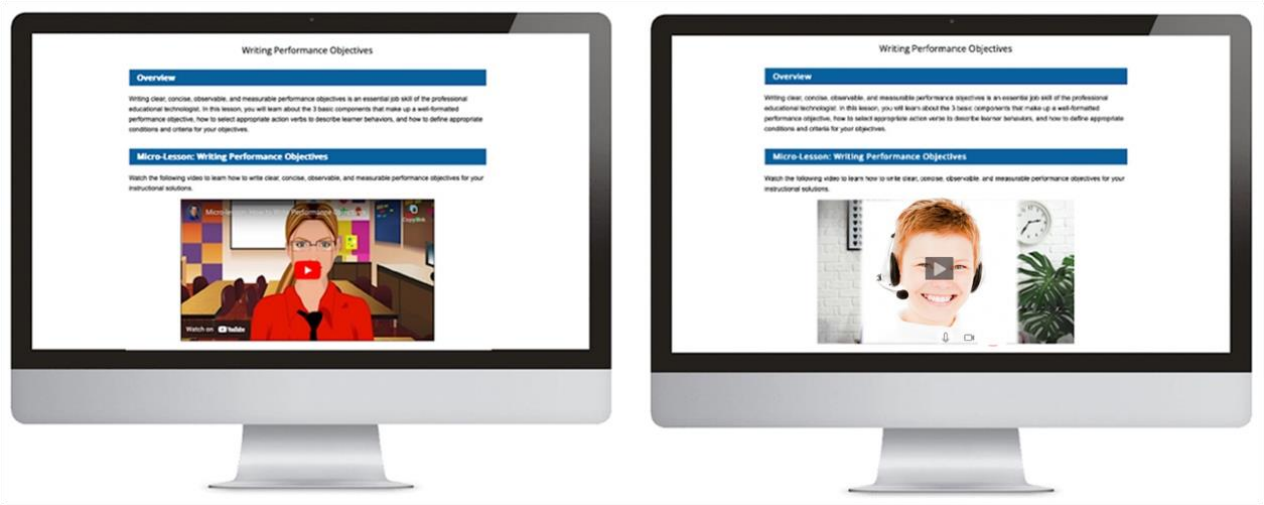

Figure 1: **Screenshots of the Two Micro-lesson Videos (The Original Video on the Left & The Multimedia the Enhanced Video on the Right)**

Table 2 provides a comparison of the original and revised lesson videos based on the *Principles of Multimedia Learning.*

Table 2: A Comparison of Original and Multimedia Enhanced Micro-lesson Videos Based on Mayer's (2009) Principles of Multimedia Learning

Multimedia Principles	Original Micro-Lesson	Multimedia Enhanced Micro-Lesson
Multimedia Principle. "People learn better from words and pictures than from words alone" (Mayer, 2009, p. 223).	Slides included few visual elements to support the instructional message.	Slides included relevant visual elements to convey and support the instructional message.
Spatial Contiguity Principle. "Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen" (Mayer, 2009, p. 135).	Few graphics were included in the presentation. In some instances, images appeared and disappeared while the narration continued.	On-screen text and related graphics were presented together on the slides. The voiceover audio narration was synchronized to correspond with the on-screen text and pictures.
Temporal Contiguity Principle. "Students learn better when corresponding words and pictures are presented simultaneously rather than successively" (Mayer, 2009, p. 153).	While there was no latency between the voiceover audio and on-screen text, few graphics were used to reinforce the instructional message.	On-screen text and related graphics were physically close together, so they always appeared on the screen at the same time. There was no latency between the voiceover audio narration and the visuals.
Modality Principle. "People learn more deeply from pictures and spoken words than from pictures and printed words" (Mayer, 2009, p. 200).	No animations were included in any of the slides. Visual elements were limited to presenting tables and essential graphics. Use of on-screen text was used liberally and corresponded with voiceover audio narration.	No animations were included in any of the slides. The use of on-screen text was limited to key ideas, lists, or examples. Visual elements corresponded with and supported the voiceover audio narration.
Redundancy Principle. "People learn better from graphics and narration than from graphics, narration, and printed text" (Mayer, 2009, p. 118).	Slides consisted primarily of on-screen text with few essential graphics, accompanied by a voiceover audio narration.	Slides consisted primarily of graphics and voiceover audio narration. On-screen text was limited to key ideas, lists, or examples.
Coherence Principle. "People learn better when extraneous material is excluded rather than included" (Mayer, 2009, p. 89).	Slides included word-by-word transcripts of the voiceover audio narration with few pictures. All visual elements were contextual and helped to convey and support the instructional message.	Slides included only essential words, pictures, and sound in the form of the voiceover audio narration. All visual elements were contextual and helped to convey and support the instructional message.
Personalization Principle. "People learn better from multimedia presentations when words are in conversational style rather than formal style" (Mayer, 2009, p. 242).	The speaker used a conversational, informal style throughout the voiceover audio narration. The language was simple and casual.	The speaker used a conversational, informal style throughout the voiceover audio narration. The language was simple and casual.

Multimedia Principles	Original Micro-Lesson	Multimedia Enhanced Micro-Lesson
Voice Principle. "People learn better when the narration is spoken in a human voice rather than a machine voice" (Mayer, 2009, p. 242).	The voiceover audio narration was created using a computer-generated machine voice that approximated a human voice. The 30-second introduction was presented by an animated non-human instructor.	The voiceover audio narration was recorded by the instructor. The 30-second introduction was presented by the instructor enabling learners to see her face.
Segmenting Principle. "People learn better from a multimedia message is presented in user-paced segments rather than as a continuous unit" (Mayer, 2009, p. 175).	The video must be watched as a continuous unit from beginning to end.	The video is split up into small segments with built-in reflection points in the form of quiz questions. When a viewer approaches a reflection point, the video pauses, presents a question, and waits for the learner to input a response.

The Pre/Post Skill Checks were created using SoftChalk's Quiz feature to securely collect assessment data in a SoftChalk Cloud ScoreCenter. To assess knowledge comprehension, a 10-question multiple choice quiz was developed. To assess learners' ability to perform a targeted skill, an open-ended question asking learners to write a performance objective to address a predetermined instructional goal was developed. The quiz portion was automatically graded and uploaded to the SoftChalk Cloud ScoreCenter.

The open-ended question was graded by two faculty with extensive knowledge of the subject matter. The resultant original and enhanced micro-lessons were embedded into 2 sections of 2 graduate courses over the 2021 Spring and Summer Modules. All 4 sections were offered 100% online in an accelerated, 7-week format. Students enrolled in section 01 of both courses were assigned to the treatment group and received the multimedia enhanced micro-lesson. Students enrolled in section 02 of both courses were assigned to the comparison group and received the original micro-lesson. A total of 89 students participated in the study.

In Week 1, the treatment and comparison groups took a Pre-Skills Check (pre-test) as a normal part of the learning activities for that week. They had 7 days to complete the assignment. The link and instructions for accessing the Pre-Skills Check was provided on the Course Schedule and Welcome Announcement for the 4 course sections included in the study.

In Week 2, students completed a *Writing Performance Objectives* micro-lesson as a normal part of the learning activities for that week. The students in the comparison group completed the original version of the micro-lesson while the treatment group completed the micro-lesson with the multimedia enhanced video. The links and instructions for accessing the micro-lessons and Post-Skills Checks were provided through the Course Schedules and Week 2 Announcements in the participating courses.

In Week 4, students were informed of their participation in an action research study. Through a class discussion blog post, they were given an opportunity to view both versions of the micro-lesson video and weigh in on which video format—the original video or the enhanced video designed with the *Principles of Multimedia Learning*—they preferred to learn from and why. Quantitative data from the Pre/Post Skills Checks as well as qualitative data from learners' perceptions and preferences regarding multimedia design for microlearning were analyzed to answer the four research questions addressed in this study.

Results

Paired Samples T-Tests were used to address Research Question 1 (What *is the effect of a micro-lesson on learners' knowledge and skill acquisition?).* The Paired Samples T-Tests were run on the pre- and post-knowledge and skills checks to determine if the micro-lessons had a statistically significant positive impact on learners' knowledge and skills acquisition. Table 3 presents Means, Standard Deviations, and Std. Error Means for all participants on the Pre/Post knowledge and skills checks and Table 4 presents the Paired Samples T-Tests for knowledge and skills acquisition using Pre/Post Skills Checks data.

Table 3: Means, Standard Deviations and Std. Error Means for all Participants on the Pre/Post Knowledge and Skills Checks

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error Mean
Pre-Skills Check						
Knowledge	89	0	100.00	59.21	21.962	2.328
Skills	89	0	4.00	2.69	1.144	.12131
Post-Skills Check						
Knowledge	89	0	100.00	89.37	15.590	1.653
Skills	89	0	4.00	3.38	3.376	.10178

Table 4: Paired Samples T-Tests for Knowledge and Skills Acquisition

Paired Samples Test									
		Paired Differences							
Knowledge and Skills Assessment		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	**Pre/Post-Knowledge**	-24.157	20.215	2.143	-28.416	-19.899	-11.274	88	<.001
Pair 2	**Pre/Post-Skills**	-.68539	1.08025	.11451	-.91295	-.45784	-5.986	88	.000

As illustrated in Tables 3 and 4 above, there was a statistically significant difference between Pre-Skills and Post-Skills scores for knowledge acquisition (t = -11.274, p < 0.001). On average, Post-Skills scores for knowledge acquisition were 24.27 points, (41%) higher than Pre-Skills scores. Likewise, there was a statistically significant difference between Pre-Skills and Post-Skills scores for skills acquisition (t = -5.986, p = 0.000). On average, Post-Skills scores for skills acquisition were .69 points (17.25%) higher than Pre-Skills scores.

A One-Way ANCOVA test was conducted to address Research Question 2 (*What is the effect of a redesigned micro-lesson video using Mayer's (2009) Principles of Multimedia Learning* on *learners' knowledge acquisition?)* The One-Way ANCOVA used the Pre-Skills Check as the covariate to control for the unmatched groups to determine if a statistically significant difference existed between the Pre/Post-Skills scores of learners who completed the original micro-lesson over the Pre/Post-Skills scores of learners who completed the multimedia enhanced micro-lesson. Table 5 presents Means, Standard Deviations, and Std. Error Means for the Comparison and Treatments groups on the Pre/Post-Skills Checks.

Table 5: Means, Standard Deviations and Std. Error Means for the Comparison and Treatments Groups on the Pre-Skills and Post-Skills Checks for Knowledge Acquisition

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean
Pre-Skills Check					
	Treatment Group	53	58.87	22.102	3.032
	Comparison Group	36	59.72	22.072	3.684
	Total (All)	89	59.21	21.962	2.328
Post-Skills Check					
	Treatment Group	53	83.02	14.086	1.935
	Comparison Group	36	83.89	17.773	2.962
	Total (All)	89	83.37	15.590	1.653

As illustrated in Table 5 above, the variance in the Means for the Pre/Post-Skills Checks for the comparison and treatment groups are very close. Table 6 presents the results for the One-Way ANCOVA with the dependent variable being the Post-Skills Check with the Pre-Skills Check as the covariate.

Table 6: One-Way ANCOVA Analysis for the Differences in Post-Skills Check Mean Scores Between the Treatment and Comparison Groups for Knowledge Acquisition

Source	Type II Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	4583.048[a]	2	2291.524	11.726	.000	.214
Intercept	43332.598	1	43332.598	221.746	.000	.721
V2	4566.820	1	4566.820	23.370	.000	.214
V1	7.453	1	7.453	.038	.846	.000
Error	16805.716	86	195.415			
Total	640000.000	89				
Corrected Total	21388.764	88				

a. R Squared = .214 (Adjusted R Squared = .196)

Based on the results of the analysis, there was no statistically significant difference in the performance of learners in the treatment group versus the comparison group, $F(1, 86) = 0.038$, $p = 0.846$. Hence, there was no statistically significant difference in learners' knowledge acquisition based on Pre/Post-Skills scores of learners who completed the original micro-lesson over the Pre/Post-Skills scores of learners who completed the micro-lesson with the multimedia enhanced video.

Another One-Way ANCOVA test was conducted to address Research Question 3 (*What is the effect of a redesigned micro-lesson video using Mayer's (2009) Principles of Multimedia Learning on learners' ability to perform a targeted skill?)* This One-Way ANCOVA also used the Pre-Skills Check as the covariate to control for the unmatched groups to determine if a statistically significant difference existed between learners in the treatment and comparison group's ability to perform a targeted skill as evidenced by the Pre/Post-Skills scores. Table 7 presents the results for the One-Way ANCOVA with the dependent variable being the Post-Skills Check with the Pre-Skills Check as the covariate.

Table 7: **One-Way ANCOVA Analysis for the Differences in Post-Skills Check Mean Scores Between the Treatment and Comparison Groups for Skill Acquisition**

Source	Type II Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	19.125[a]	2	9.562	13.261	.000	.236
Intercept	70.370	1	70.370	97.586	.000	.532
PRESKILLS	19.083	1	19.083	26.463	.000	.235
GROUP	.080	1	.080	.010	.741	.001
Error	62.016	86	.7			
Total	1095.750	89				
Corrected Total	81.140	88				

a. R Squared = .236 (Adjusted R Squared = .218)

Based on the results of the analysis, there was no statistically significant difference in the performance of learners in the treatment group versus the comparison group, F (1, 86) = 0.110, p = 0.741. Hence, there was no statistically significant difference in learners' *ability to perform a targeted skill* based on Pre/Post-Skills scores of learners who completed the original micro-lesson over the Pre/Post-Skills scores of learners who completed the multimedia enhanced micro-lesson video.

To address Research Question 4 (*What are learners' perceptions regarding multimedia design for microlearning based on how they prefer to consume content?),* participants were given an opportunity to view both versions of the micro-lesson video and then were asked which video format (the original video or the multimedia enhanced video), they preferred to learn from and why. A total of 170 responses were collected regarding learners' preferences on two versions of the micro-lesson video. Each response was analyzed to find out learners' video preferences. The responses revealed that 100% of the students preferred the second video which was designed according to the multimedia design principles. The following is a highlight of the principles that were most frequently addressed by the participants.

The **Personalization Principle** from the *Principles of Multimedia Learning* (Mayer, 2009), received the most comments. It states, "people learn better from multimedia presentations when words are in a conversational style rather than a formal style" (Mayer, 2009, p. 242). Students reflected that they had a more positive experience with the video with the human voice in comparison to the machine-generated narration. One of the students shared, "after watching both videos, it was easy to conclude that the second video was the better option for me. I felt the first video was too robotic and the second video had an actual person talking." Another student reported, "video one felt overly formal and robotic at times." Students also underscored the human voice's engaging aspect sharing, "in video two the instructor's voice was pleasant and engaging while in video one the voice was too boring for me," and "I prefer the second video as listening to a real person, real voice is more engaging to me than an automated tone. I like that the instructor is in front." The reflections also revealed that the personalization of the voice had an impact on students' attention. One student shared the challenges experienced trying to focus with the video with the mechanical voice, explaining, "the voice in the first video was very monotonous…my mind wondered." Another student concurred, noting, "I would choose video #2...The voice in the other video makes it more difficult to focus on what they're trying to teach learners..."

The second, most frequently referred to principle was the **Segmenting Principle**. Mayer (2021) notes, "in segmenting, we break a complex multimedia message into smaller parts that are presented sequentially with pacing under the learner's control" (p. 315). Different from the first micro-lesson video that presented the content in 1 continuous segment, the content of the redesigned, multimedia enhanced micro-lesson was segmented by questions inserted throughout the video for learners to pause and respond to. In addition, the re-designed micro-lesson allowed learners to navigate back and forth to different sections of the lesson.

Students' reflections mostly revealed positive views regarding the segmenting principle. One explained, "the…2nd video…had mini quizzes throughout the presentation, this is something that will help learners follow along better and allow for them to take small breaks from listening to use the knowledge they just acquired to answer a quick question." Several student responses underlined the significance of the segmenting principle in terms of maintaining their attention, stating observations such as, "I also liked that I was being quizzed every so often to make sure that I was paying attention" and "...the quizzes throughout required that your attention remain focused." Another student added, "the quizzes also help the learner stop and assess what he or she is learning."

The students' responses indicated that the quiz component not only supported the segmenting principle, but also provided them with valuable feedback. For instance, a student noted, "the interactive quiz is also very helpful as it highlights the important information about performance objectives and provides immediate feedback." Another student added in more detail, "video 2 asked questions to make the learner stop and think about what was being discussed in the video…this is great to help learners stimulate their thinking process and enhance their critical thinking skills."

Evidence of the **Multimedia Principle** was also highlighted by the participants as an enhancement of the revised micro-lesson. According to Mayer (2009), this principle posits that "people learn better from words and pictures than from words alone" (p. 223). While the original micro-lesson did include images and a robotic narrator, it had a lot more text on the screen. The revised micro-lesson was designed with much more attention to balancing the human narrator's words, the words on the screen, and relevant images to support the message. Regarding this principle, one student noted, "the second video included graphics and multimedia that related to the instructional content provided by the instructor which allowed me to stay engaged and give the video my full attention." Other students added: "….I was able to focus on the content of the second video better because the pictures were more aligned with the narration without having too many words on the screen;" "video 2 engaged me into the content…The visuals weren't too much and overwhelming. It was just the right amount of media in order to comprehend;" and "the graphics on the second video were more relatable to the lesson which kept me engaged." This supports Mayer's (2021) findings that "when learners engage in this mental act of integrating verbal and pictorial representations, they are engaging in the process of generative processing…help[ing] the learner[s] hold corresponding verbal and pictorial representations in working memory at the same time" (p. 117-118).

Another principle that was referred to in the qualitative responses was the **Spatial Contiguity Principle** that states, "people learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen" (Mayer, 2009, p. 135). A student noted, "I like that video two had the on-screen text and related graphics presented together with narration that went with the text and images." Other students observed, "I prefer the second video…[it] was easier to follow, provided relevant graphics that supported the instructional message," and, "I was able to focus on the content of the second video better because the pictures were more aligned with the narration without having too many words on the screen."

Students' feedback on the open-ended question revealed that they overwhelmingly preferred the revised micro-lesson and had very detailed observations regarding the design and pedagogical differences between the 2 videos.

Discussion

The purpose of this action research study was twofold: (1) determine if micro-lessons integrated into online courses enhanced learners' knowledge and skills attainment; and (2) determine if redesigned micro-lesson

videos based on Mayer's (2009) *Principles of Multimedia Learning* provided learners with an instructional advantage over videos that were not designed with those principles. Regarding the effect of a micro-lesson on learners' *knowledge and skill acquisition* (RQ1), the introduction of micro-lessons into the curriculum did statistically significantly affect the learners' understanding of the concepts addressed in the lessons (Knowledge acquisition: $t = -11.274$, $p < 0.001$; Skills Acquisition: $t = -5.986$, $p = 0.000$).

For knowledge acquisition, with a mean of 59.21 on the Pre-Skills Check and 83.37 on the Post-Skills Check, the average gain between the Pre/Post-Skills Checks was 24.27, a 41% increase in performance between assessments. Similarly, Post-Skills scores for skills acquisition were .69 points (17.25%) higher than the Pre-Skills scores. These results support the continued use of micro-lessons to help improve the attainment of important knowledge and skills throughout a sequence of instruction.

Regarding the effect of redesigned micro-lesson videos based on Mayer's (2009) *Principles of Multimedia Learning* on learners' *knowledge acquisition* (RQ2), there was no statistically significant difference in the performance of learners in the treatment group versus the comparison group, $F(1, 86) = 0.038$, $p = 0.846$. Hence, the redesigned videos did not give learners in the treatment group an academic advantage over those in the comparison group. Regarding the effect of redesigned, multimedia enhanced micro-lesson on learners' *ability to perform a targeted skill* (RQ3), there was no statistically significant difference in the performance of learners in the treatment group versus the comparison group, $F(1, 86) = 0.110$, $p = 0.741$. Hence, the redesigned videos did not give learners in the treatment group an academic advantage over those in the comparison group.

Regarding learners' perceptions and preferences about *multimedia design for microlearning* (RQ4), students overwhelmingly preferred the multimedia enhanced videos. In fact, 100% (N = 86) of the participants who contributed to the open-ended question said they preferred to learn from the enhanced redesigned video over the original. They cited the **Personalization**, **Segmenting**, **Multimedia**, and **Spatial Contiguity** principles to justify their responses. Hence, while the redesigned videos did not give learners in the treatment group an academic advantage over those in the comparison group, all learners indicated that they preferred to learn from the multimedia enhanced video over the original video.

Limitations

While the integration of micro-lessons into academic coursework has been shown through this study to positively impact learners' knowledge acquisition and ability to perform a targeted skill, several noteworthy limitations in the design of the study may have impacted the outcomes. For example, the inability to apply randomization or matching to equate the two groups was an important limitation that should be addressed in a follow up study. Another possible limitation was the makeup of the two groups. The courses where the study took place are the first two courses' students typically take in the graduate program and are generally taken concurrently in the first module of the program. Yet, due to substantial program growth over the past year-and-a-half, these courses may not have been available when some students were admitted to the program, and thus, they may have been pre-exposed to the skills and knowledge addressed in the microlearning lessons through other courses taken prior to the start of this study. Moreover, of the 89 participants, 37 (42%) received a passing score on the Pre-Skills Check, indicating the possibility of prior exposure to the instructional content.

One important consideration regarding the population, is that this study was conducted using graduate students who have already demonstrated successful academic track records. These learners would have been successful notwithstanding the quality of the instructional resources they were provided through their

courses. It should also be noted that when Mayer (2009) conducted experimental studies of the *Principles of Multimedia Learning*, he examined each principle independently of the others. In addition, this study applied all the multimedia principles to the design of the enhanced video, which could have muddied the waters regarding how individual principles impacted how learners received and processed information. A future follow-up study could adopt Mayer's methodology to determine how individual multimedia principles might enhance learning and retention of knowledge and skills.

Summary & Next Steps

Based on the findings of this study, the introduction of micro-lessons to fully web-based courses did statistically significantly enhance learners' understanding of the major concepts addressed in the lessons. This outcome supports the integration of micro-lessons into academic courses to support knowledge and skills acquisition. Regarding multimedia design for microlearning, while the application of Mayer's (2009) *Principles of Multimedia Learning* to the development of the enhanced video did not provide learners with a statistically significant advantage in knowledge and skills acquisition, when students were asked which format they preferred to learn from, they overwhelmingly selected the redesigned video format.

Of the 89 students who participated in the study, 86 responded to the follow-up question, and of those students, 86 students (100%) indicated a strong preference for the redesigned video. Through their comments they referenced several multimedia principles as a justification for their preference. This revelation suggests that investing the additional time to develop enhanced videos based on multimedia principles is a worthwhile endeavor, even if it does not directly lead to improved achievement scores.

Considering the central limitations of this study, additional research on microlearning integration and multimedia design for learning in e-learning is needed and warranted. Next steps for the researchers will focus on addressing the limitations in subsequent experiments to determine if they can improve learning outcomes to justify the design of videos based on the multimedia design principles. Another related line of inquiry will be to examine the impact of adding interactive guided practice activities in the design of micro-lessons.

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